ANALYSIS OF VENTRICULAR LATE POTENTIALS IN HIGH RESOLUTION ECG RECORDS BY TIME-FREQUENCY REPRESENTATIONS

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***Abstract*- This study proposes the application of different linear and quadratic Time-Frequency Representations (TFR) for the analysis of Ventricular Late Potentials (VLP) in High-Resolution Electrocardiographic (HRECG) records. The TFR used here were Short-Time Fourier Transform (STFT), Wigner-Ville (WV) and Choi-Williams (CW) distributions. These techniques were used to evaluate the risk of Ventricular Tachycardia (VT) in post-infarction patients. For comparison, the same analysis was made on HRECG records of subjects presenting Low Arrhythmia Risk (LAR). For all TFR and both populations, two indexes on the Time-Frequency (T-F) plane were considered: a) Energy of VLP normalized with respect to the total energy of the beat (EN_{TOTAL}) and b) Energy of VLP normalized with respect to the energy of QRS complex (EN_{QRS}). The results indicate that the two T-F indexes of the LAR group show higher mean values than those of the VT group, for all TFR used. In addition, the EN_{QRS} index for the WV distribution obtained the best valuation as a diagnostic test, showing the highest sensitivity and specificity values. It can be concluded that T-F analysis of HRECG is a promissory technique of diagnosis to identify post-infarct patients with high risk of VT.**

***Keywords*- Ventricular Late Potentials, High-Resolution ECG, Time-Frequency Representations.**

I. INTRODUCTION

In developed countries, cardiovascular pathologies represent the first cause of mortality (NHLBI, 2007). Within this group of pathologies, the Acute Myocardial Infarction (AMI) is responsible for 75% of heart disease mortality. From the total population suffering an AMI, about 25% to a 35% die within the first 48 hours of the ischemic event (Merck, 2007). The patients who survive the infarct can develop during the first year a malignant Ventricular Tachycardia (VT) with a probable death, caused by a reentry mechanism generated in the infarction zone, which alters the pattern of normal conduction of the cardiac electrical impulse (Wimmer *et al.*, 2006).

A special type of cardiac electrical signals called Ventricular Late Potentials (VLP) can be detected in post-infarct patients with this reentry arrhythmogenic substrate. The VLP are cardiac signals of very low amplitude (between 1 and 20 μV) and high frequential content (between 40 and 250 Hz), which are located at the end of the QRS complex and at the beginning of the ST segment (Berbari and Steinberg, 2000). The generation of these potentials in post-infarct myocardium patients indicates a greater risk to develop spontaneous VT that can possibly lead to the patient's sudden death. Therefore, an early detection of VLP can identify post-infarct patients with a high risk of VT and, consequently, provide them a preventive medical treatment (Kunavarapu and Bloomfield, 2004).

Due to their particular characteristics, the VLP are not detectable in the conventional surface electrocardiogram (ECG). For this reason, other electrocardiographic techniques must be used in order to detect these cardiac micropotentials. The High-Resolution ECG (HRECG) is the specific electrocardiographic technique oriented to the detection of VLP. This technique has a greater amplitude resolution (converters A/D of 12 or more bits are generally used) and a sample rate greater than 1 KHz (AAMI, 1998). The main problem of HRECG in VLP detection is linked to the low Signal-to-Noise Ratio (SNR) of these micropotentials, which are usually masked by noise. The most widely used technique to improve the SNR of VLP is signal averaging with temporal coherence, that consists on averaging a set of heart beats, previously detected and aligned. The application of this method results in the so-called signal-averaged HRECG (AAMI, 1998).

In a previous study, a time-domain analysis of VLP in signal-averaged HRECG records was made (Orosco and Laciar, 2006). In such work, the classical temporal indexes for VT risk evaluation (Breithard *et al.*, 1991) were computed and acceptable results were obtained. However, the temporal indexes show a high dependence on background noise. Therefore, other techniques should be investigated as well.

The last few years have seen a growing interest on time-frequency analysis of biological signals. Representations like the Short-Time Fourier Transform (STFT), the Vigner-Wille (VW) and Choi-Williams (CW) distributions, are used in this area. For instance, some of these techniques were used to extract and analyze early ictal activity in electroencefalographic signals (Sum *et al.,* 2001); and to analyze heart rate variability in ECG records (Chan *et al.*, 2001). In respiratory sleep disorders, T-F techniques are used to detect arousals (Cho *et al.*, 2005). It is also worth-mentioning the analysis of changes of nonstationarity and time variation of neuro-